

BELLCOMM, INC.

SUBJECT: Trip Report: Soil Mechanics
Conference at MSC,
March 7, 8, 1966 - Case 340

DATE: April 18, 1966

FROM: R. K. McFarland

ABSTRACT

A conference on soil mechanics from the Apollo viewpoint was held at MSC on March 7, 8, 1966, to discuss the present status of the soil mechanics efforts being conducted by NASA. The conference was attended by a number of soil mechanics specialists, by representatives of NASA, Bellcomm, and companies involved in this phase of the Apollo program. The purpose of the meeting was to review the Apollo related soil mechanics efforts that have been conducted, and to obtain recommendations from the specialists on the remaining efforts that should be performed.

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MEMORANDUM FOR FILE

A conference on soil mechanics from the Apollo viewpoint was held at MSC on March 7, 8, 1966, to discuss the present status of the soil mechanics efforts being conducted by NASA. The conference was attended by a number of soil mechanics specialists, by representatives of NASA, Bellcomm, and companies involved in this phase of the Apollo program. The purpose of the meeting was to review the Apollo related soil mechanics efforts that have been conducted, and to obtain recommendations from the specialists on the remaining efforts that should be performed.

The specialists present at the meeting were:

Prof. G. A. Leonards	Purdue University
John Lowe, III	Tippetts-Abbett-McCarthy-Stratton
Prof. F. E. Richart, Jr.	Univ. of Michigan
W. G. Shockley	Waterways Experiment Station
Prof. T. William Lambe	MIT
Prof. R. F. Scott	Calif. Institute of Technology
Prof. H. Bolton Seed	Univ. of California

The agenda for the meeting was as follows:

Introduction	Dr. L. Reiffel, NASA
LEM Design and Performance	R. A. Hilderman, Grumman
LEM Landing Dynamics Studies and Surveyor Efforts	R. Black, Bendix

(A) LEM Landing Gear Design and Performance	J. A. Chamberlin and other NASA/MSC
(B) MSC Landing Dynamics Studies	
(C) Apollo Probe Studies	
(D) Problem of Extrapolation from Surveyor Data or Probe Data to LEM	
LRC Probes and Data Obtained Thus Far	R. S. Kraemer, Philco
LRC Probe Data Interpretation and Future Plans	Dr. G. W. Brooks, NASA/LRC
Sandia Penetrators and Soil Simulation Work	M. L. Kramm, Sandia
Soil Mechanics Capabilities of the Engineering Surveyor	L. Jaffe, JPL
Adhesion Studies	J. Ryan, Douglas
Cohesive Effects in Soils	Dr. J. Halajian, Grumman
Lunar Mobility Studies	Dr. G. Bekker, General Motors
Results of the Russian Luna 9 Mission	L. Jaffe
Projectile Impact Studies in Soils	D. E. Gault, NASA/Ames

Discussion and Recommendations

Primary topics considered during the critical discussion and recommendation period of the meeting were as follows, in order of decreasing priority:

1. Assuming Surveyor success, what is an adequate program to assure confidence in describing LEM landability at the Surveyor site:
 - (a) Are Apollo launched probes an adequate complement to current lunar surface measurements to be performed by Surveyor?
 - (b) If not, what additional lunar measurements and/or earth-based work should be implemented?

2. Assuming Surveyor success, what additional measurements and data should be required to allow extrapolation of soil mechanics data to points considerably removed from the measurement site?
3. If there is no Surveyor data, we can assume a backup system to provide soil mechanics data consisting of Apollo probes launched before touchdown. What should be the nature of these probes?
4. Discuss the nature and purpose of soil mechanics measurements subsequent to the first manned landing, re: future landing sites, astronaut mobility, vehicle mobility, construction problems, basic science, etc.

The presentations were a general review of the related aspects of the Apollo program. Of interest, it was stated by Dr. Jaffe of JPL that no attempt would be made to conduct the erosion experiment on the first landed Surveyor. In addition, computer efforts at MSC have shown that a LEM could land on a 12° slope, with a 4 psi constant reaction force soil with no inertial response.

The conclusions presented by the soils specialists, as a result of the presentations made, were unanimous in several points, as summarized. Information on the lunar surface soil characteristics at present is not adequate to provide a high confidence that the LEM can make a stable landing on the lunar surface. Dr. Lambe stated that under normal circumstances the risks were not excessive by his standards, however, considering the importance of the Apollo program, and the catastrophic nature of an unstable LEM landing, efforts should be made to reduce the risk involved. They felt that the Engineering Surveyor should have been designed to provide more adequate tactile data on the lunar surface, and that the present vehicle will offer little meaningful information. Mr. Lowe and Dr. Leonards felt that the geologic mapping efforts should be intensified, to minimize as much as possible by this method the presence of geologic inhomogenieties in prospective LEM landing sites, however this opinion was not shared by Mr. Shockley. Dr. Richart expressed the opinion that if the lunar soil is marginal, the erosion problem due to the retro motor exhaust impingement on the soil would provide an additional hazard, perhaps more serious than the question of the soil bearing strength. Dr. Leonard felt that concern should be given to the possible presence of a crust on the lunar surface that could add another dimension of complexity in determining the compatibility of the lunar surface for a LEM landing.

When the specialists were asked to state a single soil measurement they would make to obtain meaningful lunar surface tactile data, there was a consensus that a static bearing strength measurement would be most desirable. On discussing the LRC penetrometer, and the dynamics of soil impact, it was agreed that little pertinent theory or experience exists that would be applicable to the problem, and to the interpretation of the acceleration-time signatures from impact sensors. Drs. Scott, Shockley, and Seed did express some confidence in the penetrometer concept, and felt that with concerted effort the penetrometer sensor could be applied to the LEM effectively. In addition, it was recommended by the group that an effort be made to utilize the soil mechanics profession more actively in the related NASA programs.

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